

On inverse power cluster-size distributions generated by the Random Domino Automaton

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The Random Domino Automaton (RDA)—a slowly driven system in the form of a one-dimensional stochastic cellular automaton—was introduced as a stylized simple model of earthquake statistics to provide a basis for the interrelation of Gutenberg–Richter law and Omori law with the waiting time distribution for earthquakes. The Gutenberg–Richter distribution provides a universal relationship between the frequency of earthquakes and their size, and—if earthquake magnitude is measured by their energy (or seismic moment)—it has the form of an inverse power-law distribution.

In the RDA model, energy-related clusters can grow, merge, and disintegrate (trigger avalanches) depending on specific system parameters, which in stationary conditions is described in terms of the coupled recurrence relation for cluster-size statistics. This formulation proves appropriate for studying the role of these mechanisms in the formation of discrete inverse power-law distributions, or discrete Zeta distributions.

By asymptotic analysis of the relationship between the avalanche probability and the resulting stationary cluster-size distribution, we show that the convolution term in the governing equation, which encodes cluster merging, plays a decisive role in generating inverse power-law relations for a wide regime of parameters.

We conclude by pointing out an interesting connection of RDA-type systems with well-known Catalan-like integer sequences (Catalan, Motzkin, Schröder numbers) and also mention the generalization of RDA to the geometry of the Bethe lattice.

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